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EDUCATION OF CIVIL ENGINEERS: TRAINING FOR CIVIL ENGINEERING

by Benjamin A. Whisler, M. ASCE

BOARD OF DIRECTION

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FOREWORD

Following a recommendation in 1951 of the ECPD Committee on Adequacy and Standards of Engineering Education, the American Society for Engineering Education appointed in May, 1952, a Committee on Evaluation of Engineering Education. This committee issued a preliminary report in October, 1953, an interim report in June, 1954, and a final report which was published in the Journal of Engineering Education for September, 1955. In brief, the committee recommends increased emphasis on the basic sciences, the engineering sciences, and the humanistic and social studies, accompanied necessarily by a de-emphasis of engineering art and practice, and elimination of or reduction in time allotted to courses which have a high vocational or skill content.

The papers by L. E. Grinter (Proceedings Paper 858) and by Benjamin A. Whisler (Proceedings Paper 859) consider the implications of the Final Report as it concerns the education of civil engineers.

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EDUCATION OF CIVIL ENGINEERS: TRAINING FOR CIVIL ENGINEERING

Benjamin A. Whisler,[1] M. ASCE

Those of you who are familiar with the problems of engineering education are familiar with the American Society for Engineering Education. For those who are not, I would like to point out that for several decades this organization has been the predominant influence upon the attitudes and policies of engineering educators, colleges, and curricula. It is a society of some eight thousand members drawn from virtually all engineering schools of the country and from all academic ranks. Industry is well represented by individual members. Although civil engineers played a prominent part in its growth, in recent years their influence has waned until now the leaders in the organization are predominantly from other fields. It is this change in leadership which is bringing about changes in engineering education which, in my opinion, are not to the best interests of the civil engineering field.

The leadership in the American Society for Engineering Education is now largely from those fields closely associated with the manufacturing industries, and this leadership is unduly influenced by the needs and interests of a few large industries which maintain very large programs of research and development. This is all very well for certain fields of engineering activity such as electrical engineering and mechanical engineering, but conditions are so very different in the field of civil engineering that changes which may be reasonable in other fields should not be applied to the field of civil engineering.

Present trends in engineering education are toward the inclusion of much more mathematics, physics (including atomic physics), theoretical mechanics, and similar courses. These courses are being expanded in order to prepare the graduate engineer for entry into development and research activities and are at the expense of those courses which emphasize the truly engineering aspects of the curricula. We are approaching the point where our students will be trained only as scientists and not as engineers.

In order to determine whether or not such changes are appropriate in the training of civil engineers, we should examine some of the factors which distinguish the civil engineer from other engineers. The historical development of the field of civil engineering has resulted in civil engineering's being closely associated with public works. The report of the A.S.C.E. Committee on Employment Conditions published in 1953 showed that about thirty-seven per cent of all civil engineers are employed by municipal, state, and federal government agencies. An additional twenty-eight per cent were employed in private engineering practice, much of which is closely associated with public works such as sewage treatment plants, water treatment plants, and superhighways. In no other field of engineering does the employment of engineers in positions in government agencies or associated with government projects so predominate.

Another factor which is of significance is that, outside of government, civil

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engineers are largely employed by small organizations. Consequently relatively few civil engineering graduates have the benefit of formal training or orientation courses such as those provided by the large corporations who employ engineers.

Perhaps the most important feature of employment of civil engineers is that they are closely associated with heavy construction. A recent survey of the employment of graduates of a large eastern university showed that nearly one-half of its graduates go immediately to field positions in heavy construction or to positions closely associated with construction projects. Another third go directly to operation and maintenance positions which usually have large elements of construction involved. Thus, educators in civil engineering must keep in mind the fact that, in general, students must be trained for positions in the office or the field which are closely allied with the construction of non-duplicated projects and not with the mass-produced products of general industry.

The practice of engineering in any field is even today a combination of both art and science. Many problems cannot be solved by the straightforward application of mathematical and physical principles but must depend upon judgment based upon experience. For many reasons such judgment must be used much more by the civil engineer than by engineers in other fields. He works with extremely variable and incompletely understood materials such as soils. He is prevented from using the best engineering solutions because he must satisfy the desires of non-engineering public authorities such as municipal councils and elected officials, and he is restricted by antiquated legal building codes. Consequently he is continually required to make decisions which represent compromises with the theoretically best solution to a problem. The educational institution can do little to provide the experience needed to make such decisions, but it should do everything it can to provide a basis for making such judgments by indicating to the student the part such judgment plays in the work of the engineer and by providing in his education the opportunity for exercising judgment based upon his limited experience and knowledge. Such training cannot be a part of basic courses in mathematics and physics but must be a part of the advanced courses at the junior and senior level in which the principles of science are applied to specific, practical engineering problems.

Research is needed in the field of civil engineering just as in other fields in order to develop more economical methods of producing the desired results in all branches of the field. Such research is being continually conducted, but in civil engineering this is rarely done by large private industrial organizations as is the case in other fields. Research in civil engineering is being largely conducted, as in the past, by the engineering colleges of the country supplemented in a few fields by independent, industry-supported organizations such as the Portland Cement Association and by government research such as the Bureau of Public Roads work on pavements. None of these organizations employ many new engineers each year, and most of the engineers newly employed by them are men with experience in the field who have become interested in the research activities.

It is obvious, therefore, that the colleges of the country are training civil engineers to a large extent for positions associated directly with heavy construction. These men will perform design, supervision, or operations functions in this field, and the best of them will progress to important positions of responsibility in their organizations. They will become the chief engineers or presidents of railroads, the chief engineers of highway departments or

government bureaus, the owners of consulting firms, and the owners of construction companies.

What kind of an education should be given to the young men who are to occupy responsible civil engineering positions at any level of advancement? As we do not know, and the student rarely knows, what specific branch of the civil engineering field the student will enter until near the end of his college career, it is obvious that his college education must be sufficiently broad to enable him to fill adequately any starting position in any branch of the field. Nor do we know whether his principal function will be in design, construction, or operation, or in a combination of these. Consequently his college education must prepare him for all three.

On the other hand we do know certain specific requirements for the education of the student who is going to enter the general field of civil engineering. First, he must be an engineer with all the basic training in mathematics, physics, and mechanics necessary for the civil engineering field. He must have a knowledge of the basic principles of design in the principal materials of construction: reinforced concrete, steel, asphalt, and soils. He should understand the basic principles involved in all fields of civil engineering such as structures, sanitation, hydraulics, surveying, transportation, and others, so he may later build upon this background in his ultimate specialty and may be generally informed in the whole field. Because the young civil engineer so frequently must make written reports early in his career, he must be particularly well grounded in the use of the English language. Some breadth must be given his education, so his curriculum must include appropriate courses in the areas of the humanities, the social sciences, and the fine arts.

With these requirements in mind and particularly remembering that the student does not know exactly what he will be doing after graduation and that his employer will not provide any special training courses, it is apparent that the curriculum for the civil engineering student should be broad in nature, well balanced between courses covering both the science and the art of engineering, sufficiently technical to enable the student to be useful to his employer very soon, strong in the area of communications through the use of the English language, and as rich as possible in non-engineering subjects.

Since the Wickenden Report of the early nineteen thirties, engineering colleges have been changing their curricula to meet these requirements. That there has been general agreement on what constitutes a reasonable and effective compromise among these requirements within the framework of a four-year curriculum is evidenced by the similarity of curricula at most four-year institutions. It might be concluded that we have actually developed the best possible curricula under the circumstances and that normal and gradual modifications would keep the curricula up to date.

Many leaders in engineering education, however, believe that this stability in curricula is evidence of stagnation and that new developments, particularly in atomic science and electronics, require a complete revision of our methods of training engineers and subject matter covered. Perhaps this is true in certain fields, but it does not appear to be so in civil engineering, for such developments can have only small and peripheral effects upon the field of civil engineering. Our field has made steady progress over the years, but actually there has been no startlingly new concept since reinforced concrete came into use several decades ago, and there promises to be none in the near future. This is only natural, for civil engineering works have been built for thousands of years and may be expected to be in a more mature state of development than those in other fields. Our progress has been along such lines as the

better understanding of the principles underlying soils and hydrology, the more economical use of materials, the use of photogrammetric mapping, the reduction in the costs of earth moving, and similar developments. These modern developments must be brought to the attention of our students.

The proposals made for changes in all engineering curricula include the addition of more mathematics beyond the calculus, atomic physics, or atomic engineering beyond that which is necessary to keep the student informed concerning progress in the field, "solid state" physics or mechanics, and advanced electronics. These proposals may have their place in other fields, but in civil engineering they would be virtually useless. If injected into the civil engineering curriculum, they would, of necessity, force out something already taught, and almost surely this would be work in the advanced civil engineering subjects. This must not be permitted, for even now we certainly cannot point with pride to the thoroughness with which we cover any given subject. How much better it is for the young graduate civil engineer to be able to participate intelligently in the sound economic study of a highway location problem or the organization of a construction program than to be able to compute the efficiency of an atomic reactor. We must remember what a civil engineer is and what he does.

For the occasional civil engineer who gets into an unusual position or who becomes a research worker, there will always be the need for specialized knowledge along certain lines. When this need becomes apparent, he can always obtain it as he has in the past. As do most civil engineers who develop intellectually as the years pass, he may obtain the knowledge through his own efforts in the library or through his technical magazines. He may also take formal graduate work in a university.

When we are considering engineering curricula, let us remember that the field of civil engineering is very different from other fields of engineering. The civil engineer is apt to work for a public agency, in construction, by himself, and he is apt to have a wide variety of problems in his day's work. Let us not pattern our civil engineering education after the engineering education of the mass-production industries where research and development positions have become predominant, but let us continue to design our civil engineering education for civil engineers.

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The technical papers published in the past year are identified by number below. Technical-division sponsorship is indicated by an abbreviation at the end of each Paper Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. Papers sponsored by the Board of Direction are identified by the symbols (BD). For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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